STRONG MESOSPHERIC ELECTRIC FIELDS AND TROPOSPHERE-MESOSPHERE COUPLING

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ABSTRACT

Troposphere-mesosphere coupling features are considered in the case when the effects of strong mesospheric electric fields are allowed for, and electron relaxation cooling in the mesosphere due to disturbances in the tropospheric conductivity is discussed. The effects are considered of these processes on the ionospheric conductivity.

INTRODUCTION

The study of electrical coupling between the troposphere and the mesosphere is an important problem related to atmospheric electrodynamics [1]. Observations have revealed strong electric fields of up to 10 V/m (see, for example, [2, 3]), which suggests that the mesosphere should not be treated as a passive element but as an active element in the atmospheric circuit. The occurrence of transient optical emissions in the mesosphere and lower ionosphere called sprites also supports the concept of strong mesospheric electric fields (see, for example, the recent review [4]). All this requires the search for new electrodynamic mechanisms for the effects of disturbances in tropospheric conductivity on the state of the lower ionosphere; one such mechanism has been discussed in [5, 6] where it has been found that the subionospheric VLF propagation anomaly is related to earthquakes and nuclear accidents.

THE TROPOSPHERE-MESOSPHERE ELECTRIC CIRCUIT

The electrodynamic troposphere-ionosphere coupling is treated using the model of a troposphere-mesosphere electric circuit which consists of a localized or global-scale powerful source of the mesospheric current 10^{-8}–10^{-9} A/m^2, a local ground level (or troposphere-stratosphere) resistance, a local mesospheric load resistance for the mesospheric source, and the resistance of the global atmospheric layer between the ground and the lower boundary of the ionosphere approximately 200 Ohm. The electric current discharge density in the global capacitor under undisturbed conditions (fair-weather current, see, for example, [7]) can be neglected. Also during undisturbed conditions, the tropospheric resistance is much greater than the mesospheric resistance. Then during undisturbed conditions, the integral mesospheric source loading is equal to the mesospheric resistance, i.e., the electrical troposphere-mesosphere coupling does not appear.

During disturbed conditions, the tropospheric resistance can decrease by an order of magnitude and more due to, for example, an increase in the level of near-earth radiation in the vicinity of strong earthquakes or during accidents at nuclear plants with the discharge of radioactive materials (see, for example, [5, 6]). Consequently, the ratio between the tropospheric resistance and the mesospheric resistance changes, and this leads to a change in the integral mesospheric source loading. Then the strong electric field intensity becomes dependable on the tropospheric resistance. Because of an increase in the tropospheric conductivity, the decrease in the integral mesospheric source loading and the tropospheric resistance, in turn, results in a corresponding decrease in the electric field intensity and the electron temperature in the mesosphere: the ionospheric electron cooling "law" under the influence of disturbances in tropospheric conductivity when strong mesospheric electric fields occur. Thus, strong mesospheric electric fields result in an additional electrodynamic troposphere-mesosphere coupling during disturbed conditions.

To estimate the effect of the decrease in the mesospheric electric field intensity on changes in lower ionosphere parameters, we have used the well known system of equations, the energy balance equation (in terms of the electron

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[1] **Acknowledgments.** The work is supported by Science and Technology Center in Ukraine Grant 1773 to Kharkiv V. Karazin National University.

temperature), the two continuity equations in the electron density and the positive-ion density in the stratified inhomogeneous weakly-ionized plasma, and the condition of quasi-neutrality.

Numerical simulations show that the resulting decrease in the effective electron collision frequency plays a key role. The lowering of the lower boundary of the ionosphere was observed, for example, in [5, 6] in VLF signals propagated over nuclear plants during accidents with the discharge of radioactive materials into the atmosphere.

DISCUSSION

Thus, strong electric fields occurring naturally in the mesosphere can result in troposphere-ionosphere electrodynamic links the manifestations of which are observed most clearly during strong disturbances of different nature in atmospheric conductivity. The atmosphere can be affected by strong earthquakes, volcano eruptions, rocket launch (see, for example, [8, 9]), accidents at nuclear plants with the discharge of radioactive materials, and other natural and anthropogenic disturbances.

Under such conditions, a decrease in the strong mesospheric electric field intensity is expected, and consequently, a relaxation electron cooling at the mesospheric heights and essential conductivity changes in the ionospheric D region occur. The last enables radio wave techniques to be used for remotely probing these poorly understood physical processes.

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